

# Chlorate Levels in Dairy Products Produced and Consumed in Ireland

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# Introduction

- Chlorate is a residue formed as a consequence of chlorine degradation;
  - Chlorate is a 'goitrogen' and therefore, it negatively effects the function of the thyroid gland.
  - This is especially concerning for those with underdeveloped thyroid glands, e.g., infants and young children.
- **COMMISSION REGULATION (EU) 2020/749** outlines a limit of 0.10 mg/kg for chlorate in milk in its ready to use form (ready to use form as specified by the manufacturer).
  - There are no further distinctions made for different types of dairy products.
- Notwithstanding the absence of specific limits for dairy products chlorate, residue has previously been detected in cream, yoghurt and milk powder (EFSA, 2015; Kettlitz et al., 2016).
- However, there is a scarcity of data regarding chlorate levels in dairy products produced and consumed in Ireland.

## Research objective

- The objective of this research was to develop baseline levels of chlorate in staple dairy foods produced and consumed in Ireland.
- Such data may be useful for government bodies (DAFM) when representing Ireland at EU level during future negotiations on appropriate limits for chlorate in milk and dairy products.

## Staple dairy products

Dairy Product	Defining Characteristics
Whole Milk	Standardised to 3.5% fat
Whipping Cream	38 to 40% fat content
Yoghurt	Full fat natural, blueberry, raspberry & strawberry
Cheddar	Mature white with 30 to 36% fat
Butter	Maximum 2% salt & minimum 80% fat



## Manufacturers of products that were sampled

- 8 x manufacturers of milk
- 5 x cream manufacturers
- 6 x butter manufacturers
- 4 x cheese manufacturers
- 4 x yoghurt manufacturers

Most popular brands based on market share data were identified and linked back to point of manufacturer.

## Manufacturer codes used



# Materials & Methods

- Sampling 4 times during 2021– February, May, August & November
- Each sampling period extends to approximately 6 weeks to facilitate the collection of products from varying batches.
- Samples are identified by their brand name, but must bear the correct origin code to be included in the study.
- Products are purchased in major retailers in the south and east of the country.
- Stored on ice whilst being transported and refrigerated prior to freezing.
- Analysed using ultra performance liquid chromatography coupled with tandem mass spectrometry (UPLC – MS/ MS) in Teagasc, Ashtown.

## Minimum reporting levels of chlorate;

- Milk & cream = 0.0020 mg/kg
- Butter, cheese & yoghurt = 0.01 mg/kg

**In total 1,278 dairy product samples were analysed**



**Products produced on the island of Ireland were targeted as opposed to the Republic only**

## Determining sample sizes for each dairy product based on product consumption

Dairy Product	kg/Person /Day	Population	Total Consumption (kg/Day)	Confidence Interval (%)	Margin of Error (%)	Sample Size
Milk	0.120	3,192,701	380,250	95	5	320
Cream	0.0014	3,192,701	4470	95	7	200
Butter	0.0007	3,192,701	2235	95	6	240
Cheese	0.0060	3,192,701	19,475	95	8	160
Yoghurt	0.027	3,192,701	84,926	95	8	520

Consumption (kg/person/day) for each respective product is extrapolated from data presented by National Adult Nutrition Survey (NANS) [15,16]. Population figures are sourced from the National Adult Nutrition Survey (NANS) [16]. Total consumption is an estimated figure and was calculated by multiplying the consumption (kg/person/day) by the population.

# Results

## The mean levels of chlorate in samples of different dairy products

Product	Sampled ( <i>n</i> =)	Proportion Detected	Mean (mg kg <sup>-1</sup> )	SD
Whole Milk	317	0.47	0.0088	0.01
Cream	199	0.51	0.0057	0.004
★ Butter	178	0.01	0.019	0.001
Cheese	144	0.01	0.023	N/A
Natural Yoghurt	148	0.59	0.055	0.040
Blueberry Yoghurt	85	0.54	0.067	0.060
Raspberry Yoghurt	103	0.60	0.077	0.097
Strawberry Yoghurt	104	0.56	0.095	0.132

N/A; no standard deviation to present.

## Occurrence rates and mean levels of chlorate in milk and cream produced by different manufacturers

Manufacturer	A	B	C	D	E	F	G	H	I
<b>Milk</b>									
Total Samples	40	40	40	40	37	40	40	40	N/A
Prop. Detected	0.18	0.40	0.68	0.28	0.24	0.40	0.90	0.70	N/A
LS Mean	0.0025 <sup>a</sup>	0.0068 <sup>ab</sup>	0.0070 <sup>ab</sup>	0.0045 <sup>a</sup>	0.0063 <sup>ab</sup>	0.0055 <sup>a</sup>	0.0156 <sup>b</sup>	0.0090 <sup>ab</sup>	N/A
SE	0.0038	0.0025	0.0019	0.0031	0.0034	0.0025	0.0017	0.0019	N/A
<b>Cream</b>									
Total Samples	40		40	39		40			40
Prop. Detected	0.18	N/A	0.58	0.79	N/A	0.43	N/A	N/A	0.58
LS Mean	0.0026 <sup>a</sup>		0.0056 <sup>a</sup>	0.0083 <sup>b</sup>		0.0045 <sup>a</sup>			0.0039 <sup>a</sup>
SE	0.0013		0.0007	0.0006		0.0009			0.0007

All results in this table are presented 'within column'. Prop. Detected; proportion of samples analysed in which chlorate was detected above the reporting limit. LS Mean and SE values are presented as mg kg<sup>-1</sup> of chlorate. N/A; samples were not collected from this manufacturer. Where different superscripts are present the differences are significant ( $p \leq 0.05$ ); where common superscripts are present the differences are insignificant ( $p > 0.05$ ).



## Proportion detected and mean levels of chlorate in yoghurts produced by different manufacturers

Product	J	K	L	M
<b>Natural Yoghurt</b>				
Total Samples	30	38	40	40
Prop. Detected	0.50	0.87	0	1.00
LS Mean	0.046 <sup>a</sup>	0.060 <sup>a</sup>	--	0.055 <sup>a</sup>
SE	0.01	0.007	--	0.006
<b>Blueberry Yoghurt</b>				
Total Samples	24	23	38	N/A
Prop. Detected	0.58	1.00	0.24	N/A
LS Mean	0.041 <sup>a</sup>	0.103 <sup>b</sup>	0.018 <sup>a</sup>	N/A
SE	0.013	0.01	0.016	N/A
<b>Raspberry Yoghurt</b>				
Total Samples	23	40	40	N/A
Prop. Detected	0.74	1.00	0.13	N/A
LS Mean	0.03 <sup>a</sup>	0.104 <sup>b</sup>	0.03 <sup>ab</sup>	N/A
SE	0.022	0.015	0.041	N/A
<b>Strawberry Yoghurt</b>				
Total Samples	24	40	40	N/A
Prop. Detected	0.75	1.00	0	N/A
LS Mean	0.027 <sup>a</sup>	0.126 <sup>b</sup>	--	N/A
SE	0.029	0.020	--	N/A

All results in this table are presented 'within column'. Prop. Detected; proportion of samples analysed in which chlorate was detected at reportable levels. LS Mean and SE values are presented as mg kg<sup>-1</sup> of chlorate. N/A; samples were not collected from this manufacturer. Where "--" is printed it signals that no results are available. Where different superscripts are present the differences are significant ( $p \leq 0.05$ ); where common superscripts are present the differences are insignificant ( $p > 0.05$ ).

## Discussion

- Despite this study being conducted in 2021 when the dairy industry in the Republic of Ireland had adopted 'chlorine-free' cleaning, **chlorate was still detected in approximately half of the milk, cream and yoghurt sampled.**

### What are the potential causes for this chlorate occurrence?

- **Chlorine still being used** on farms/ in processing plants despite the 'ban' in place – demonstrated by the differences between manufacturers.
- **Improper use of chlorinated water** on farms/ in processing plants.
- Product produced/ milk sourced for processing in **Northern Ireland where chlorine can still be used.**
- The fact that **sodium hydroxide still contains chlorate**; albeit at levels that are about 140 times lower than those found in sodium hypochlorite.
- **Added ingredients:** yoghurt – milk powder and fruit

# Chlorate in yoghurt



- Dairy powders such as SMP are included in yoghurt manufacture to increase the overall protein content of the yoghurt, thereby reducing the incidence of syneresis.
- Any chlorate residue present in powder can then translate to yoghurt



- Fruit added to yoghurts may contain chlorate due to their growth/processing as a consequence of chlorinated water use.
- Any chlorate present in the fruit will be expressed in the yoghurt.

## How do chlorate levels in Irish dairy products compare to others internationally?

- With the exception of milk, levels of chlorate in Irish dairy products were higher than those detected in other countries.
- However, the sample sizes employed in this current study were far larger than those in comparative studies.
  - For example, the yoghurt sample size in the current study was 40 times larger than that employed by Kettlitz et al. (2016).

## Are chlorate levels in Irish dairy products compliant with the maximum residue limit?

- With the exception of yoghurt, all dairy products are in compliance with the existing limit (0.10 mg/kg) that is in place for milk.

## Conclusion

- Chlorate occurrence is widespread in milk, cream and yoghurt, but virtually absent from butter and cheese.
- Notwithstanding this, the levels of chlorate detected in milk, cream, butter and cheese are largely in compliance with the existing EU limit for chlorate in milk.
  - Levels of chlorate detected in yoghurt did not comply.
- A regular and contextualised monitoring program should be implemented at national level to keep abreast with both chlorate occurrence and levels present.
  - This should be conducted in conjunction with a continued effort to reduce chlorate occurrence across the dairy chain.



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